PSEUDAMUSIUM ELLIPTICUM LIMESTONE: A NEW LITHOSTRATIGRAPHIC UNIT IN THE LOWER CARBONIFEROUS AT CASTLETON, DERBYSHIRE

by

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Summary

Certain limestones at Castleton, Derbyshire, containing the pectenid *Pseudamusium ellipticum* (Phillips), show a strong uniformity of character among themselves, but are markedly distinct from other limestones in the vicinity. Observations on the condition and distribution of the fossils suggest features of the depositional environment. Considerations of the distribution of the limestone indicate that it belongs to an isochronous unit of rock, and with further study it may prove to be a useful marker horizon in this district.

Introduction

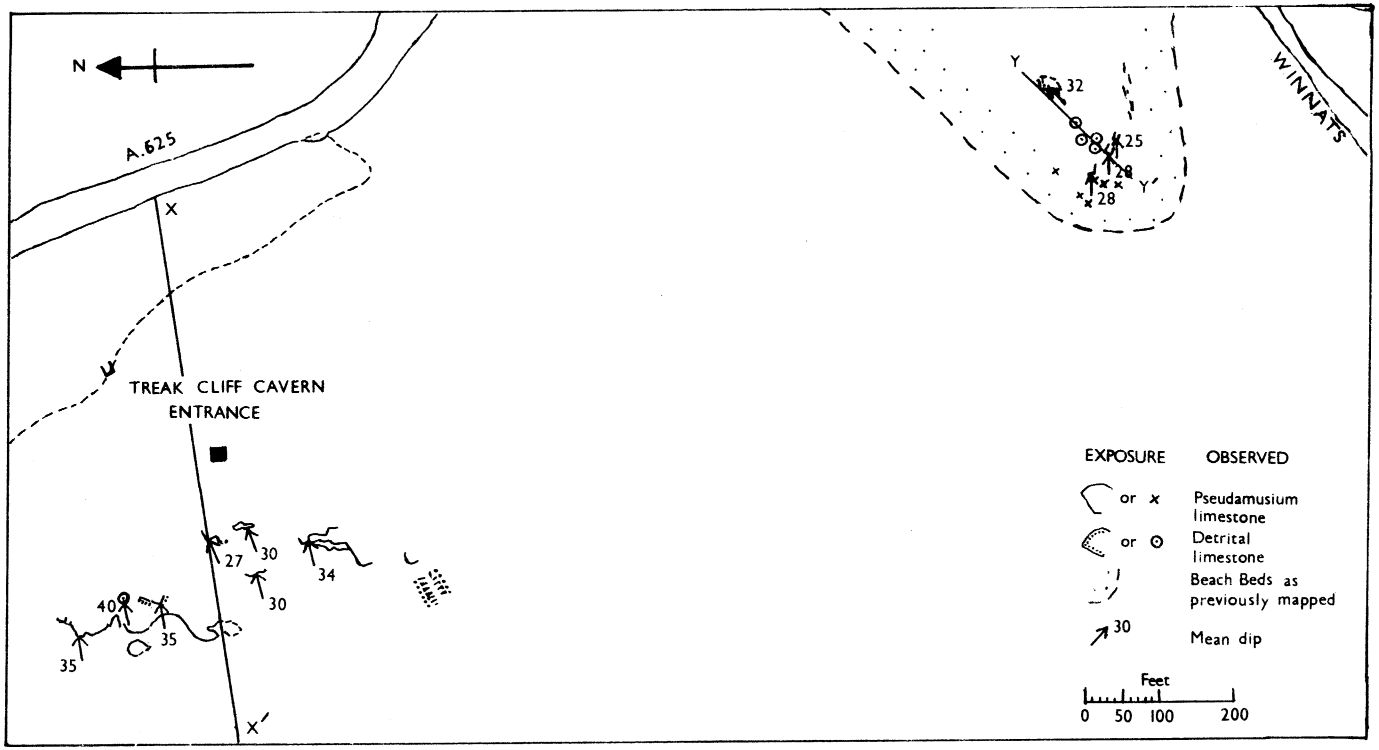
Since 1896, when Barnes and Holroyd wrote a paper "On the occurrence of a sea-beach at Castleton, Derbyshire", the lower Carboniferous rocks of this region have been studied intensively. The limestones which have received the greatest attention in recent years are those of the reef-complex. Bedding is usually obscure in these; and individual beds often show rapid lateral variation in petrology and fossil content. This makes it difficult to recognise or to trace laterally any significant features of the limestone sequence in this district.

Recently a limestone containing abundant *Pseudamusium ellipticum* (Phillips) was discovered in exposures on the eastern side of Treak Cliff hill. Subsequent study has suggested that this limestone might serve as a marker horizon in the vicinity of Castleton.

Serious work on this topic has now had to end because of other commitments. Insufficient data has been collected to allow a comprehensive examination of the *Pseudamusium ellipticum* limestone; this paper should therefore be regarded as a preliminary account which outlines some of the limestone's basic characteristics, and some of the methods considered suitable for its study.

The nature of *Pseudamusium ellipticum* limestone

Within the area shown on the map (Text-Fig. 1) two types of limestones were distinguished. These will be referred to as *Pseudamusium ellipticum* limestones and non-*Pseudamusium ellipticum* limestones. The former either contain large, concentrated pockets of *Pseudamusium ellipticum* (Phillips) (often with 50 valves per litre of rock) or lie visibly at the same horizon as such pockets.



TEXT-FIG. 1 Sketch map indicating the distribution of exposures of Pseudamusium ellipticum limestone on Treak Cliff, Derbyshire.

The latter contain only occasional P. ellipticum (rarely 2 valves per litre of rock).

A comparison was made between the faunas seen at different exposures in P. ellipticum limestone. The abundance of each species was seen to be similar at all of the localities where it was found and no species was common at one locality and absent from the others.

A comparison was also made between the faunas of the P. ellipticum limestones and those of other limestones in the area. In non-P. ellipticum limestones, pelecypods were found to be subordinate in number to brachiopods and rarely made up 25% by number of the pelecypod-brachiopod fauna. In P. ellipticum limestones, pelecypods are the most common bivalve shells. A sample of $8\frac{1}{2}$ litres of this limestone was collected from an exposure above Treak Cliff Cavern, and 233 bivalve shells were extracted. 75% of these were Pseudamusium ellipticum (Phillips), 10% were other pelecypods and 15% were brachiopods. Eighteen common species of fore-reef brachiopods, including Pleuropugnoides pleurodon (Phillips), Pugnax spp. etc. were absent from all P. ellipticum limestones examined. At least 100 other fore-reef species that have been seen locally in B_2 non-P. ellipticum limestones (see Wolfenden, 1958, pp. 894-898) were not represented. Eight species were restricted to P. ellipticum limestones.

Thus, the faunas observed at different exposures in P. ellipticum limestone are markedly similar. They differ, however, from the faunas of the other limestones exposed in the vicinity.

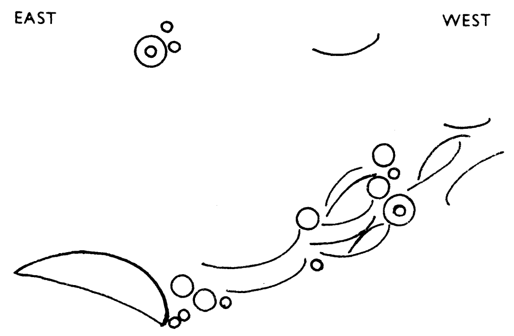
Some elements of the sedimentary environment of P. ellipticum limestone

From what has been written above, it seems reasonable that similarities may exist between the sedimentary environments of the P. ellipticum limestones in different exposures. As far as they were taken, studies made at the individual localities support this view.

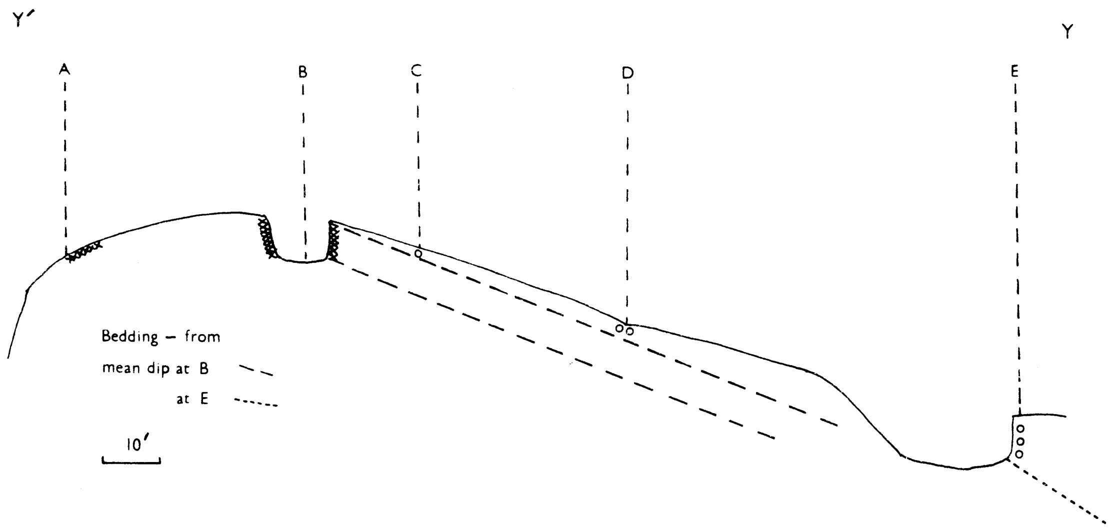
The condition and mode of distribution of the fossils were used to indicate factors in the depositional environment of the P. ellipticum limestones.

Completeness was one of the major criteria which was used to describe the condition of the fossils: it depends on their degree of fragmentation and, in the case of bivalves, their articulation. Little damage was seen in any parts of the fauna. Damaged or fragmentary shells are uncommon, typically about 10 pelecypod fragments were seen to every 100 entire P. ellipticum (Phillips) in a sample of the limestone. Most pectenids and all P. ellipticum (Phillips) observed were disarticulated. The only peleypods that were commonly found articulated were Edmondia primaeva (Portlock) and Aviculopinna mutica (McCoy), and those specimens of the borer Lithodomus which were found in vertical or near vertical positions. Most of the brachiopods seen were articulated. This evidence suggests that the pectenids, including P. ellipticum (Phillips), are not in their life positions and that their transportation did not have a strongly abrasive action.

Perhaps the most notable feature of the fossil distribution was its unevenness. Often fossils would be seen locally concentrated and elsewhere very scarce. The structure of the high concentration areas was of special interest. They were often in the form of thin lenses of limestone embedded in less fossiliferous limestone and predominantly had an easterly dip. In the majority of cases, the shells in these pockets appeared to be in contact with one another. Often individual shells showed a probable direction of origin, which was predominantly from the west (see Text-Fig. 2). Accumulations of crinoid columnals were often seen on the western sides of large shells. This evidence suggests that many of the fossils have been transported from the west, and that they came to rest against obstacles, such as large shells, with which they are still in contact. (Text-Fig. 2).



TEXT-FIG. 2 Diagram to indicate common features of shell pockets: crinoid columns and Pseudamusium ellipticum (Phillips) valves are seen to the west of an articulated Buxtonia, which appears to have obstructed their movement down the submarine slope.



TEXT-FIG. 3 Section near the Winnats (see Text-Fig. 1) suggesting the superposition of the Beach-Beds (circles) on the P. ellipticum limestones (cross-hatched).

Two major agencies that might have been responsible for the transportation of the fossils are westerly flowing currents and gravitational forces acting down an easterly dipping slope. It seems unlikely that a current which was strong enough to drag shells along the sea floor would have a small abrasive action. The fine intermediate sediment of shell "piles" suggests that currents were weak in the deposition zone. It seems unlikely that the thin shelled pectenid Pseudamusium ellipticum (Phillips) would have lived in a region typified by strong, abrasive currents. For these reasons, the importance of current action was dismissed as being negligible.

The present evidence may be explained if transportation and deposition occurred on an easterly dipping slope. The presence of such a slope was first suggested by Shirley and Horsfield (1940) to explain the dip pattern of the Castleton area, and has subsequently received support from a study of geopetal infillings of fossils (Broadhurst and Simpson, 1967).

The original slope may be responsible for the pockety distribution of fossils. It seems likely that once a pile began to accumulate, then its first members would naturally afford new obstacles and would hinder or terminate the movement of other shells down the slope. It would thus grow, in contrast with the surrounding sediments which would not afford many places where shells could become lodged.

Finally, some comments may be made on the rate of sedimentation. It was clearly slow enough for the soft parts of the pectenids to disintegrate sufficiently to allow the valves to drift apart before they were entombed: also, the common occurrence of bryozoan colonies between layers of shells in pockets, and their presence throughout whole pockets, suggests that individual areas were free from disturbance over periods long enough to allow the growth of these colonies.

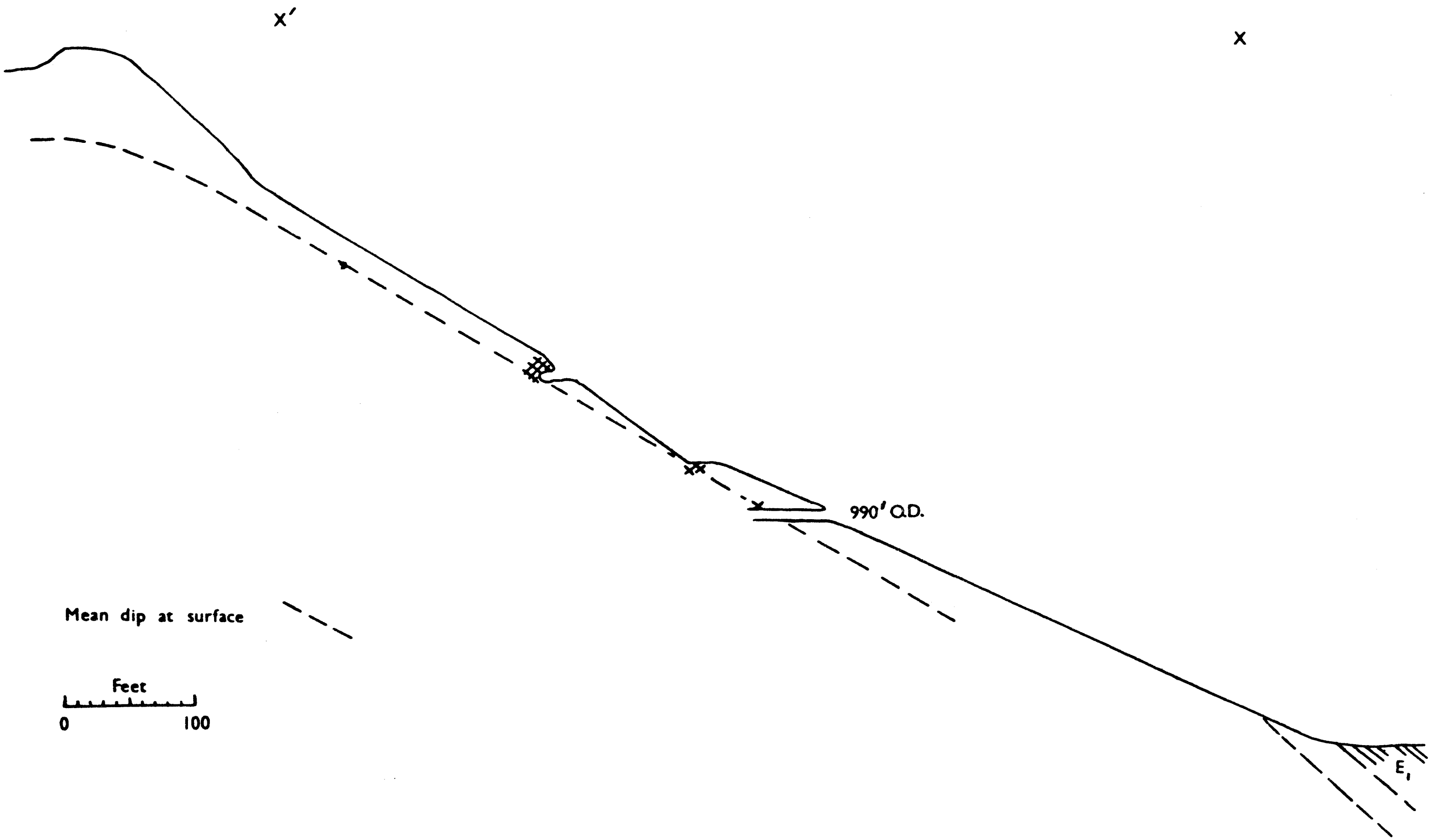
Stratigraphical relationships between the exposed sections of Pseudamusium ellipticum limestone

Having shown, above, that locally on Treak Cliff Pseudamusium ellipticum limestones form a distinct class of rocks, it is now convenient to examine the field relationships of their exposed sections, with a view to elucidating the stratigraphy.

At this point it should be noted that the limestones contain joints which show a preferred orientation, suggestive of true bedding. The spread of values of dips seen in these joints suggests that their interpretation as true bedding is not wholly satisfactory. At most exposures, structures such as shell pockets were examined to help in interpreting the data from joints, and on this basis a figure was arrived at for the dip. The inaccuracies of such figures, and the possibility that local unevennesses in true dip may be present, make any large scale interpretations uncertain.

Consider the section Y - Y' (Text-Figs. 1 and 3). If the local dips have been correctly interpreted, then the P. ellipticum limestones at B lie below the "Beach-Beds" at E. Also, large blocks of "Beach-Bed" limestone have been seen in the deep subsoil at C, and at D small exposures in "Beach-Beds" - almost certainly not loose rocks - are present. Within this section there is no evidence to suggest faulting or rapid local change of dip; and so it appears that the P. ellipticum limestones here lie below the "Beach-Beds". Unfortunately their relationship cannot be determined at present, since their contact is not exposed. The limestones exposed below A have not yielded any P. ellipticum (Phillips). In this section, upper and lower stratigraphical limits to the P. ellipticum limestone seem to be present.

P. ellipticum limestones also seem to have upper and lower limits in the exposures above Treak Cliff Cavern. The following two sections illustrate this:



TEXT-FIG. 4 Section near Treak Cliff Cavern indicating the relationship of the exposures of P. ellipticum limestone (cross hatched) to the dip.

			Thickness
A.	(i)	grey limestones with Pseudamusium ellipticum (Phillips) pockets locally; also pockets of brachiopods and shell fragments.	1 foot
	(ii)	typical P. ellipticum limestones; shell fragments rare.	20 feet
	(iii)	P. ellipticum limestones with a high percentage of pelecypod fragments.	3 feet
	(iv)	pale brown crinoidal limestone.	3 feet
B.	(i)	white limestone containing limestone pebbles, rolled shells, crinoid ossicles etc.	3 feet
	(ii)	brown, coarse grained limestone containing crinoids, shell fragments, corals etc.	8 feet
	(iii)	fine grained grey limestone containing productids, smooth spiriferids etc.	1 foot

Section (B) appears to be faulted down from its original position above a section in P. ellipticum limestone. Section (A) was measured very close to section (B), and judging from the character of the beds (Ai) and (Biii) there is a strong possibility that sections similar to (B) lay on top of (A). If this is so, then non-P. ellipticum limestones of a detrital character lay vertically above the P. ellipticum limestones at (A). Non-P. ellipticum limestones lie at the base of (A).

Other comprehensive sections in this area show non-P. ellipticum limestones with reef brachiopods and shell fragments above the highest P. ellipticum limestones. In Treak Cliff Cavern, no examples of P. ellipticum limestone have been seen in any of the sections vertically below surface exposures of the limestone; this clearly establishes lower limits to the P. ellipticum limestones at these localities. In fact, at all sufficiently large sections above Treak Cliff Cavern, there appears to be a vertical limitation of the exposed P. ellipticum limestones to an individual unit of rock, though the top or base of this unit is not always exposed.

An attempt will now be made to explain the field observations in terms of a stratigraphical theory. Clearly the period and localisation of deposition of the P. ellipticum limestone will have a control over its distribution, and these will play an important part in any stratigraphical theory.

At all localities, P. ellipticum limestones were encountered in a restricted layer. Above Treak Cliff Cavern, sections in the limestone lay in one plane, which was parallel to the apparent dip.

The suggestion of ubiquitous deposition over all of Treak Cliff hill over a long period may be dismissed immediately because of the restricted extent of P. ellipticum limestone. Prolonged deposition at one location may also be dismissed because of the vertical limitation of the limestone in many exposures. No definite decision may be reached on whether the limestone was deposited over a prolonged period in different parts of Treak Cliff hill at different times. It should be mentioned that there is no evidence to suggest such a method of deposition, and the planar exposure pattern of the P. ellipticum limestones, parallel to the apparent dip, and the absence of P. ellipticum limestone in Treak Cliff Cavern, make this theory seem unlikely.

It seems likely, therefore, that deposition did not occur over a prolonged period; it must therefore have occurred over one or more short periods. The planar pattern of outcrops suggests that deposition occurred over a single period.

Evidence of localisation of deposition has been observed above Treak Cliff Cavern - i.e. in the larger area of outcrop. In some of the higher exposures, P. ellipticum limestones passed laterally into coarser grained limestones, containing brachiopods and shell fragments but no Pseudamusium ellipticum (Phillips).

There still remains the question of whether the P. ellipticum limestone exposed near the Winnats was deposited at the same time as that near Treak Cliff Cavern. Though no conclusive evidence has yet been found on this question, certain features suggest that the two limestones are isochronous. For example, there is a marked similarity between the sequences in the two areas. (High percentage of pelecypod fragments at the base, followed by a larger thickness of limestones with fewer fragmentary shells, and capped by limestones in which brachiopods are rapidly becoming abundant). The two faunas are closely similar, yet distinct from all neighbouring faunas.

Thus it seems very likely that all P. ellipticum limestones encountered to date belong to one isochronous unit.

The age of the Pseudamusium ellipticum limestones

It was suggested in a previous section that all examples of Pseudamusium ellipticum limestone may have a similar age; and it seems reasonable that their period of deposition should be placed in an already existing zone. The goniatite Beyrichoceras rectangularum Bisat occurred in Pseudamusium ellipticum limestone at many localities. Goniatites of the Goniatites maximus Bisat group were collected near the Winnats at C (Text-Fig. 2) and other indeterminate goniatites were seen from all localities in Pseudamusium ellipticum limestone. Ford (1952) noted Posidonia becheri Bronn and a goniatite "probably of the Goniatites maximus group" from "Fairyland" in Treak Cliff Cavern, in limestones below the Pseudamusium ellipticum limestone.

The fossils cited above suggest that the Pseudamusium ellipticum limestones are of B_2 age, as might be expected from consideration of previous theories on the age of Treak Cliff's limestones (see Parkinson 1953 and 1965). The present state of theories on the B_2 subzones, and especially on the range of the species mentioned above (see Parkinson, 1965 pp. 162-164), seems unsettled and no reliable verdict on the age of these limestones can be reached at present.

Conclusions

From present evidence it appears that the Pseudamusium ellipticum limestones form a uniform class of rocks at Treak Cliff which are quite distinct from all other rocks on the hill. They were probably deposited slowly on a quiet, easterly dipping underwater slope, and most of the fossils probably reached their present positions after a short slide down this slope.

It appears that all examples of P. ellipticum limestone were deposited in one short period, in particular areas on the depositional slope: these limestones form a unit that is usually 25 feet thick. It should be remembered that non-P. ellipticum limestones were being deposited at the same time as P. ellipticum limestones.

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